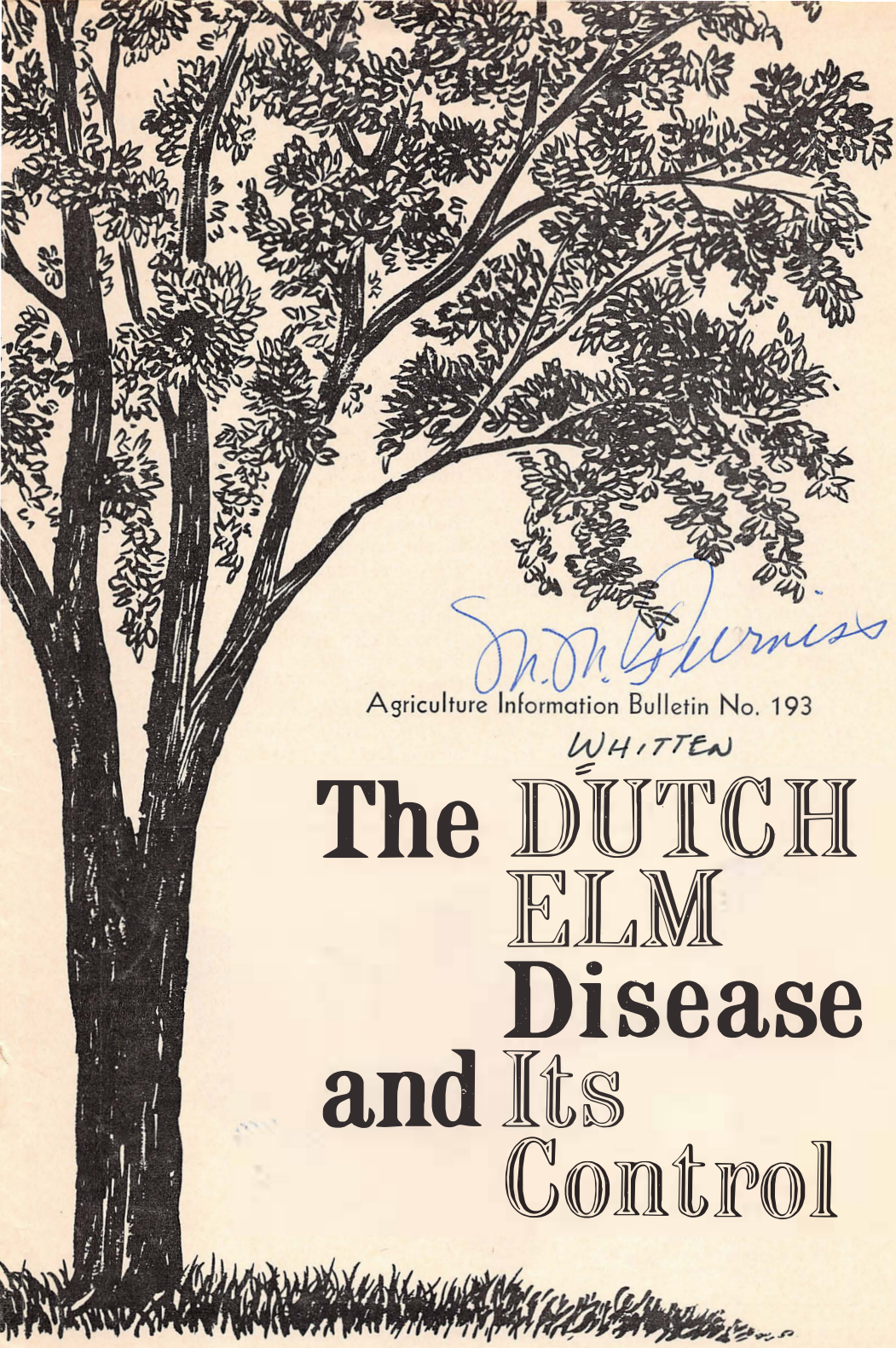

Agriculture Information Bulletin No. 193

WHITTEN

The DUTCH ELM Disease and Its Control

U. S. DEPARTMENT OF AGRICULTURE

THE DUTCH ELM DISEASE AND ITS CONTROL

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The Dutch elm disease, unknown in the Americas before 1930, has become the most destructive shade-tree disease in the United States. It was discovered in Ohio in 1930 and around the port of New York City in 1933. Since then, the disease has spread until it now occurs from the east coast to the Rocky Mountains and from North Carolina and Arkansas to the Canadian Provinces of Ontario, Quebec, and New Brunswick (fig. 1). The disease is causing extremely heavy losses of both wild and planted elms in many parts of this area.

The heavy shade tree losses from Dutch elm disease have resulted in numerous claims of protective or curative treatments. Many of these have been tested and proved to be of no practical value. In fact, some of these treatments have caused serious tree injury. At the present time, no cure for Dutch elm disease is known. Do not invest in Dutch elm disease cures without first investigating their effectiveness through your State Department of Agriculture or State Agricultural Experiment Station.

Dutch elm disease is caused by the fungus *Ceratocystis ulmi* (Buisman) C. Moreau. It attacks native and exotic species of elm. Plants in the related genera *Zelkova* and *Planera* (planertree or waterelm) have become diseased when artificially inoculated with the fungus.

Some elm species are much more seriously affected by the disease than others. Unfortunately the American elm (*Ulmus americana* L.), our most valuable native elm shade tree, is one of the most severely affected. The Siberian elm

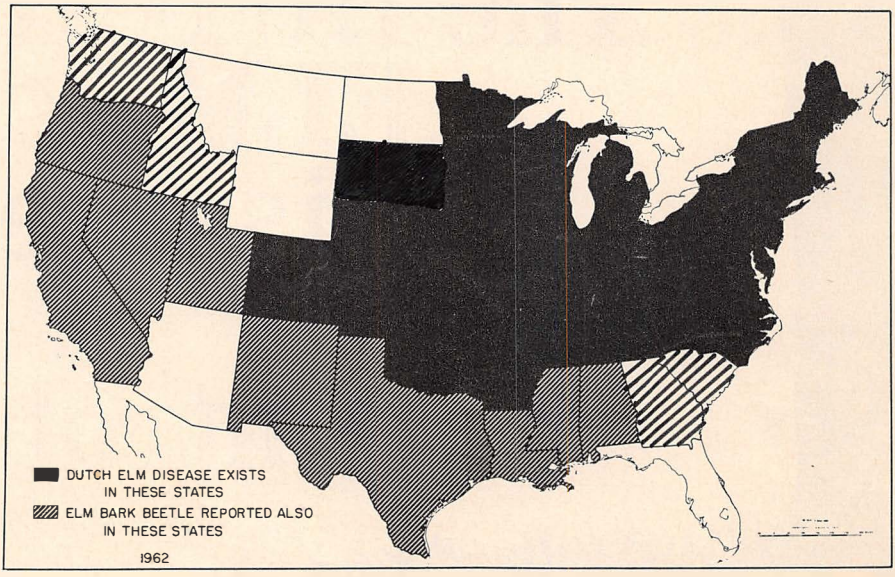

FIGURE 1.—Distribution of the Dutch elm disease and its principal carrier in 1962.

(*U. pumila* L.) and the Chinese elm (*U. parvifolia* Jacq.) are the most disease resistant of the elm species.

Dutch elm disease is one of several vascular wilt diseases attacking elm, all of which produce symptoms that look very much alike. Definite identification of one of these vascular wilt infections requires laboratory tests, which are usually made from branch specimens from the diseased tree. Facilities for making such tests are available at most Agricultural Experiment Stations. However, if Dutch elm disease is known to be well established in an area, such tests are rarely needed. This is because there is at present no cure once a tree is affected by the Dutch elm disease. Also, as will be described later, the only effective means of control for Dutch elm disease is the treatment of healthy trees to prevent them from becoming infected and the prompt destruction of all dead or dying elms, regardless of the actual cause of death.

Dutch elm disease produces a wilting and yellowing or drying of foliage, usually followed immediately by defoliation and death of the affected branches (fig. 2). The disease usually appears first on one or several branches and then spreads to other portions of the crown. Sometimes, however, the entire tree may suddenly develop disease symptoms. Infected trees commonly die within a few weeks, but some may die gradually, branch by branch, over a period of several years.

Usually trees that become infected in the spring or early summer die quickly. Those that become diseased in late summer are much less seriously affected and may even recover, unless they become re-infected.

All trees affected by the Dutch elm disease develop a brown discoloration in the water-conducting vessels of the wood. In the early spring this may be seen as brown streaks in the wood layer just under the bark of diseased branches. In other cases and later in the summer, the discoloration shows up as brown spots or a partial or complete brown circle in one or more of the outer annual rings in the cross section of a diseased branch (fig. 2).

MEANS OF SPREAD

In the United States the principal carriers of the Dutch elm disease fungus are two elm-bark beetles: The smaller European elm-bark beetle (*Scolytus multistriatus* Marsh.) and the native elm-bark beetle (*Hylurgopinus rufipes* Eichh.) (fig. 3). The habits of these two beetles are very similar, but the European species is by far the more important carrier. In fact, if both beetles are established in a region, the European species usually completely displaces the other, making it impossible to find our native species. So no further discussion of the native species will be included here.

The smaller European elm-bark beetle, like the disease, was introduced into the United States from Europe. It has already spread over an even greater area than the disease itself.

HABITS OF THE BEETLE

The smaller European elm-bark beetle will attack all species of elm, and plants of some closely related genera. The attacks made by this beetle are for either feeding or breeding. The feeding attacks are made only in living elm trees, usually in the smaller twig crotches (fig. 4).

The breeding attacks are made for laying eggs and producing broods of young. Preferred breeding places are: (1) living elms severely weakened by drought, and (2) elm material such as trees

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rapidly dying from disease or injury, storm-broken limbs, firewood, or any recently cut elm wood. But when populations of the insect become large, attempts at breeding will be made in a much greater variety of places, although living elms in good growing condition are rarely attacked for breeding purposes. Under no condition will this beetle lay eggs in wood without bark, or with bark that has dried to the point of cracking.

Feeding Habits

Adults of the smaller European elm-bark beetle feed on living elm trees throughout the entire growing season of the elm. These adults begin emerging from over-wintering broods of larvae about the time

FIGURE 2.—Typical symptoms of the Dutch elm disease: Wilting and defoliation of the tree, and (below) brown discoloration in the wood.

elms break dormancy in the spring. Depending upon temperature, the time required for a complete generation during the spring and summer varies from 35 to 45 days.

The beetles do most of their feeding in the living elms nearest the place they emerged as adults. However, the insect has been found feeding in elm trees more than 2 miles from the nearest breeding place. Where the beetle population is heavy, feeding insects may prune many small twigs from the trees. Feeding injuries are most numerous in the twig crotches nearest the outside of the crown. Sometimes the beetles feed on twig crotches in the very center of the crown.

When the feeding beetles are carrying the Dutch elm disease fungus on or in their bodies, they can cause the living tree to become diseased. How effectively these fungus-carrying beetles inoculate healthy elm trees depends on many

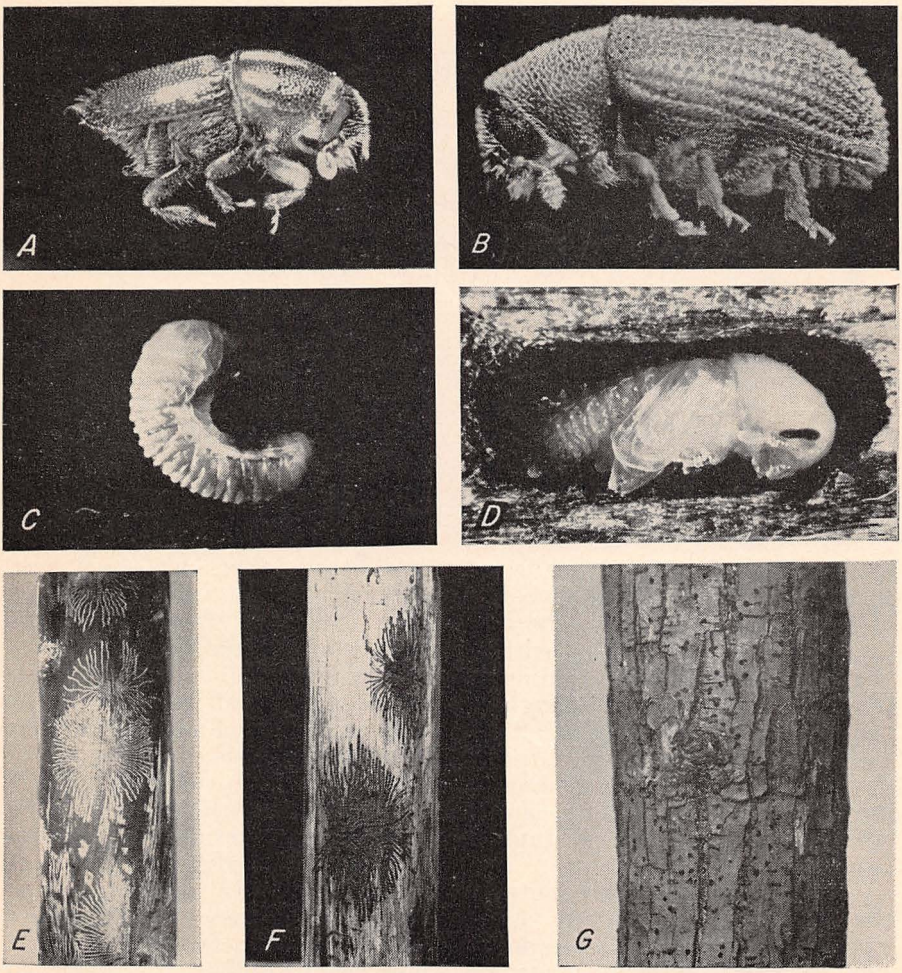

FIGURE 3.—Stages of elm-bark beetles: *A*, Adult of smaller European elm-bark beetle; *B*, adult of native elm-bark beetle; *C*, European elm-bark beetle larva; *D*, European elm-bark beetle pupa; *E*, brood gallery of European species; *F*, brood gallery of native species; and *G*, European bark-beetle emergence holes.

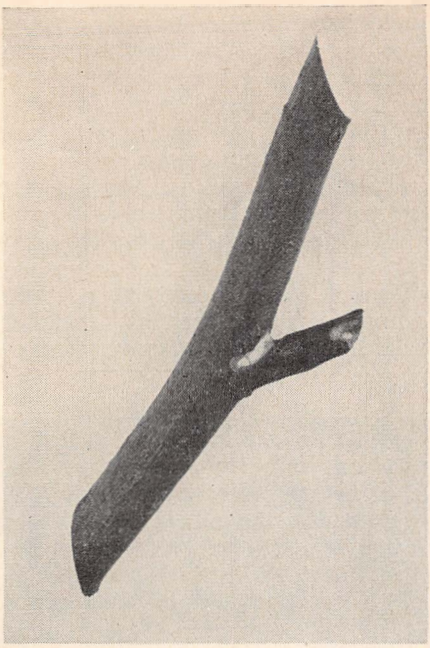

FIGURE 4.—Feeding injury made by elm-bark beetle in twig crotch. Through these injuries elms may become infected with Dutch elm disease.

things, two of which have an important bearing on any control program: Time of feeding and age of twigs fed upon.

Spring and early summer feeding (May 15 to July 30 in the Central States) is more likely to result in an elm tree becoming seriously affected by the disease than feeding before or after this time. This is because the long vessels of the elm springwood are open and functioning at this time and are near enough to the bark surface that beetles in their feeding will cut into them. Spores of the Dutch elm disease fungus introduced into these long, active spring vessels can be carried rapidly to all parts of the tree.

Vessels of wood produced later in the summer are relatively short. Spores introduced into these much shorter vessels of the summerwood move more slowly and only for short distances. These late inoculations usually result in very localized infections that seldom cause serious damage to the tree.

The long spring vessels rarely extend into twig crotches formed during the current year, and feeding in this new growth is not likely to result in general infection and death. Hence bark-beetle feeding in 1-year-old or older twig crotches during the spring and early summer is the most likely to result in a severe case of Dutch elm disease.

Breeding Habits

As soon as an elm-bark beetle emerges from its breeding place it begins searching for a place to feed or to form egg galleries. Although these beetles usually feed on living elms before mating and laying eggs, it is not necessary for them to do so. Beetles in search of suitable breeding places are in the field throughout the entire growing season of the elm. They have been known to lay eggs more than 3 miles from where they emerged as adults.

Although, as was mentioned earlier, the beetles prefer dead or dying elm material in which to establish broods of young, often they make so many attempts to breed in weakened but living trees that the trees eventually die and broods of the insect are successfully established. This has been particularly true in areas where elms have suffered from prolonged periods of drought.

Any situation that results in a large amount of recently killed, cut, or damaged elm wood may cause tremendous increases in the population of this elm-bark beetle. Conversely, anything done to reduce elm material suitable for bark-beetle breeding over a large area will greatly reduce the numbers of this insect in that area. The area must be large enough, however, to offset the effect of beetles flying in from outside.

If the smaller European elm-bark beetle is carrying the Dutch elm

disease fungus on or in its body when it makes its brood gallery, it may establish the fungus in dead or dying trees or in cut wood, where the fungus can grow as a saprophyte—a parasite living on dead matter. Later the adult beetles of the new generation developing from this brood gallery may contact and carry spores of the fungus on their bodies, and then introduce them either into living elms when they feed or into another breeding place, or both. In this way the Dutch elm disease fungus may be moved long distances any time during the entire active period of the adult beetle.

When new areas are invaded by the bark beetle and by the Dutch elm disease fungus, the latter may be present in beetle breeding places as a saprophyte for several years before the first diseased tree is found. Probably one reason for this is that beetles more often establish the fungus in their breeding galleries than in living trees. However, once the disease does appear in an area where the bark beetles are well established, it increases at an extremely rapid rate unless steps are taken to control it.

CONTROL RECOMMENDATIONS

Federal and State research workers have studied Dutch elm disease and its insect associates since 1931. Their goal has been to find an effective and economical means for preventing or at least reducing the tremendous losses caused by these pests. Methods of control have been developed, but many problems remain that only more research can solve. For example, probably the most satisfactory way to control Dutch elm disease would be to cure elm trees after they became diseased. Intensive research is being conducted on such means of plant pest control, and such a treatment may eventually be developed. At present, however, the only known way to combat Dutch elm disease is through its insect carriers. This method is indirect, but it has proved effective.

The habits of the smaller European elm-bark beetle as a carrier of the Dutch elm disease fungus make it possible to reduce losses from the disease by two approaches:

1. Prevent or reduce feeding by the beetle in living elm trees, especially during the spring and early summer when trees are most susceptible to infection. This is done by spraying.

2. Reduce the population of the beetle by eliminating the kinds of elm material that it requires for breeding. This is a matter of sanitation.

SPRAYING

Research in the control of Dutch elm disease and elm phloem necrosis by the U.S. Department of Agriculture and its State cooperators has resulted in two finished spray formulas—one for hydraulic sprayers and one for mist blowers using either methoxychlor or DDT, that have proved to be very effective in use. The finished spray for hydraulic sprayers should contain 2 percent of either methoxychlor or DDT by *weight*, and the finished spray for mist blowers should contain 12 percent of either methoxychlor or DDT by *weight*. It is recommended that these finished sprays be prepared from commercially available emulsifiable concentrates which are diluted with water to obtain the recommended percentage of insecticide. The commercial concentrates should contain xylene as a solvent to prevent tree injury.

Equipment

Sprays for controlling elm-bark beetles may be applied with either hydraulic-type sprayers or mist blowers (fig. 5). Many different makes of sprayers are capable of

doing a satisfactory job, but the equipment used must be adequate to treat the largest elm tree that may be encountered.

In test sprayings with large trees, a hydraulic sprayer having an output of 60 gallons per minute at pressures up to 600 pounds per square inch, and a mist blower with an air output of 25,000 cubic feet per minute at a 100-miles-per-hour nozzle velocity both proved satisfactory. Mist blowers should be capable of a spray output of at least 1 gallon per minute. Either piece of equipment can adequately spray elms 100 feet high when there is little or no wind.

Spray Concentrations and Dosages

For application when trees are dormant, the commercial emulsifiable concentrates of either methoxychlor or DDT should be diluted with water so that each 100 gallons of spray for use in hydraulic equipment contains 16 pounds of technical grade insecticide, and each 100 gallons of spray for use in mist blowers contains 100 pounds of insecticide.

Using hydraulic spray equipment, enough spray should be applied to thoroughly wet all bark surfaces. This usually requires from 20 to 30 gallons for an average

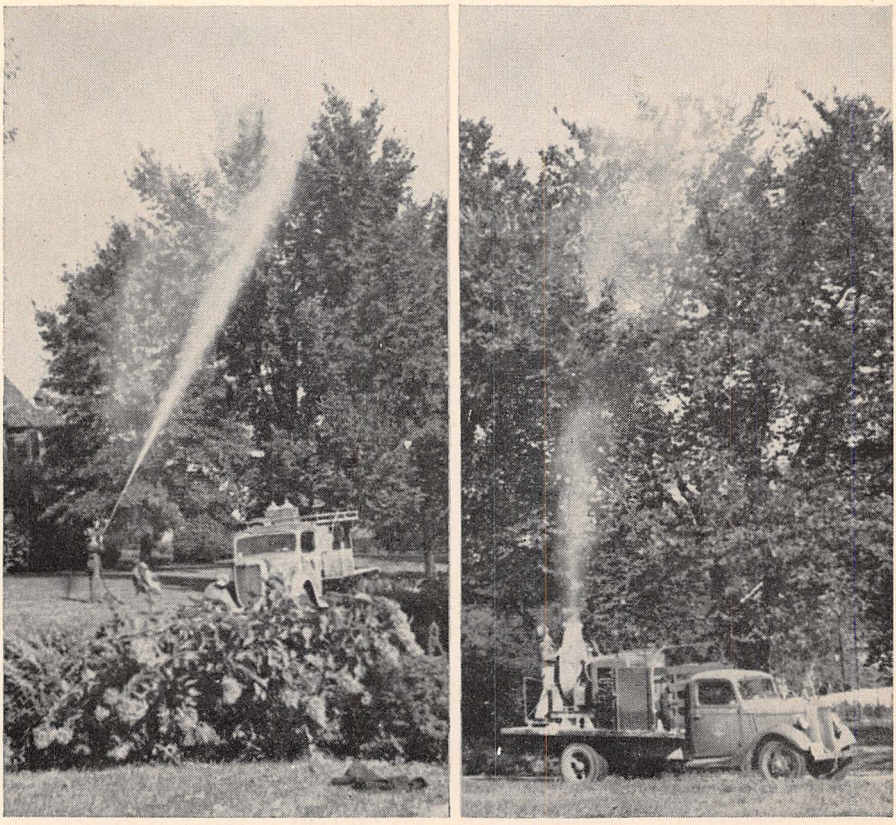

FIGURE 5.—Two types of spraying equipment: Hydraulic sprayer (left), and mist blower (right).

50-foot elm tree. For mist blowers, between 2 and 3 gallons of spray are needed to adequately treat a 50-foot elm. With hydraulic sprayers, once the bark surface is completely covered, the excess spray will run off. But when mist blowers are used, spray deposits dry so rapidly that no runoff occurs.

How To Spray

All bark surfaces must be completely covered with spray if the purpose is to prevent bark beetle feeding. Thoroughness is important. Special care should be taken to secure good coverage in the upper part of the tree crown. Complete coverage of all bark on the trunk, limbs, and twigs will prevent feeding by adults of the two elm-bark beetles.

Bark coverage can be greatly improved if two men do the work instead of one. One man sprays and the other observes. The observer should stand some distance away from the sprayer so that he can see exactly where the spray is going and how much is being deposited. Emulsion-type sprays dry very rapidly, and, unless it rains within an hour after spraying, there is very little loss of deposit from washing.

Time To Spray

Elm trees should be sprayed before the smaller European elm-bark beetle becomes active in the spring. Spraying should be done on days that have little or no wind, no rain, and temperatures above freezing. Because of the long residual effectiveness of these sprays, they can be applied any time after the elm trees lose their leaves in the fall and before the new leaves or flowers appear in the spring. Trees are then dormant, and this is called a dormant spray.

If sprays are applied for the first time when the tree is in foliage, it is impossible to adequately cover the bark. So it is best to begin the spray program when the trees are dormant. An annual dormant spray will remain effective throughout the period that elm trees are most susceptible to infection.[1]

The U.S. Fish and Wildlife Service has found methoxychlor to be less toxic to birds and animals than DDT, and the danger to birds can be further reduced by using a mist blower and spraying when the trees are dormant during the nonnesting season. Methoxychlor can be as effective as DDT in preventing beetle feeding, and it is recommended for use instead of DDT where the spray residue will pose a problem. However, methoxychlor costs more than DDT.

Precautions

Methoxychlor and DDT, like most other insecticides, are poisons and should be stored in clearly marked containers and kept away from food. Be sure to read instructions on the manufacturer's label. Persons using these sprays should avoid repeated or prolonged exposure to them. Sprays containing these chemicals should be kept away from fishponds and bird feeding stations, or such places should be covered or moved during spraying. Care should be taken to prevent pools of the spray from collecting on the ground, in the street, or on equipment where birds and animals may drink the material.

SANITATION

Sanitation, or the control of elm-bark beetles by destroying their breeding places, should be combined with spraying for effective control of the Dutch elm disease.

[1] In areas where the virus disease elm phloem necrosis occurs, the foliage should also be sprayed, since the insect *Scaphoideus luteolus* Van Duzee that carries this disease is a leaf feeder. For foliar sprays, use a 1 percent formula in hydraulic sprayers and a 6 percent formula in mist blowers.

Under most conditions, sanitation alone will not give good results. For example, in a plot of 27 square miles in Princeton, N.J., sanitation was carried on diligently for 3 years to protect the high-value elms in the very center of the plot. In the "sanitated" area, Dutch elm disease killed nearly 13 trees per 1,000 over this 3-year period and less than 20 per 1,000 in an "unsanitated" area or check plot. When the center trees in this same plot were sprayed the following 3 years, the losses averaged only 3 per 1,000 trees as compared to 31 per 1,000 trees in the check or unsprayed plot for the same period.

Here are a few reasons why sanitation may prove to be unsatisfactory for control of Dutch elm disease if used alone:

1. Adults of the smaller European elm-bark beetle can fly and carry the Dutch elm disease fungus for at least 3 miles.

2. It is often difficult for towns or property owners to carry on a sanitation program beyond the area under their jurisdiction, whereas the beetles can fly anywhere.

3. If sanitation is to be effective, *all* elm material infested with broods of the bark beetle must be located and destroyed before the adult beetles emerge. During the spring and summer months, this calls for very prompt action because the insect develops rapidly from egg to adult.

4. In many areas the elms growing in wild, low-value stands greatly outnumber those growing as shade or ornamental trees. So it is expensive and difficult to locate and destroy all breeding places. Moreover, elm trees that have no apparent signs of dead or dying wood when the tree is examined may be harboring broods of the bark beetle.

On the other side of the ledger, there are many good reasons why sanitation should be carried on. Here are just a few of them:

1. Dead and dying parts of trees frequently harbor injurious fungi and insects (fig. 6), so it is a good practice to include sanitation in any program for the care of shade trees.

2. Sanitation will definitely reduce the number of bark beetles in an area and hence will increase the effectiveness of sprays against elm-bark beetle feeding.

3. Sanitation can be begun as soon as the bark beetles invade an area. By starting early to reduce the number of bark beetles and probably the saprophytic form of the Dutch elm disease fungus, the occurrence of diseased trees can be delayed.

4. Only by sanitation can nonsymptomatic reservoirs of the Dutch elm disease fungus be destroyed.

Steps in Sanitation

1. Destroy all elm material, infested or likely to be infested with elm-bark beetles, that is found during the dormant period. Do this before the appearance of elm flowers or leaves in your area.

2. Destroy within 30 days similar material found between April and September.

3. Carry on sanitation in stands of low-value elms as conscientiously as in stands of high-value elms.

4. Search regularly and systematically for bark-beetle breeding places.

Bark-beetle-infested or likely-to be-infested elm material can be destroyed by burning, by removing and burning all the bark, or by thoroughly wetting all bark surfaces with an emulsion or solution-type spray containing 8 pounds of DDT in each 100 gallons. If solutions are used, the solvent should be No. 2 fuel oil.

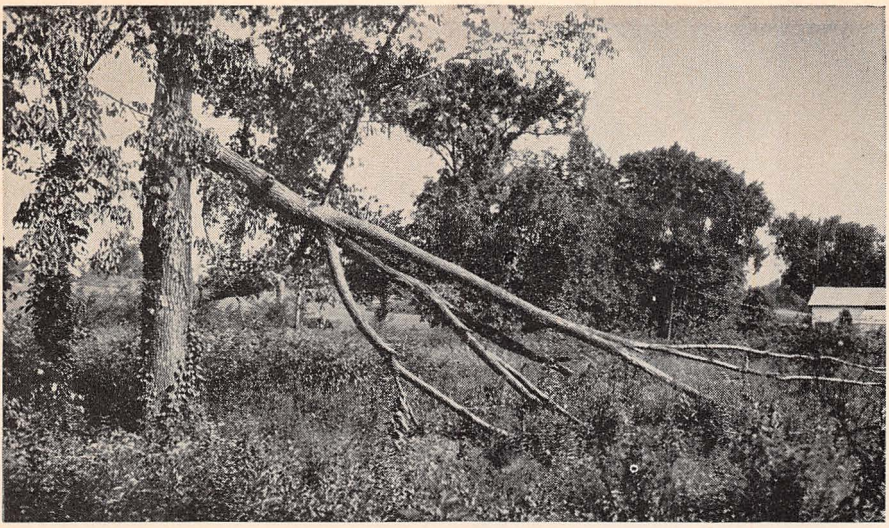

FIGURE 6.—Storm-damaged trees make ideal breeding places for bark beetles.

DEVELOPING RESISTANT ELMS

Another approach to the Dutch elm disease problem is to develop species or strains of elm that are resistant to the disease. The U.S. Department of Agriculture and State Experiment Stations have been carrying on research in this field for some time.

As some elm species are more susceptible than others to the Dutch elm disease fungus, so too are some individuals of a susceptible species more resistant to the disease than other individuals. Through inoculation of many seedlings of American elm, a very susceptible species, several trees have been obtained that suffer little damage when infected by the Dutch elm disease fungus. Similar methods have produced plants of the Chinese and Siberian elms and of *Zelkova serrata* with a very high degree of resistance to the Dutch elm disease. By use of these moderately and highly resistant selections as breeding stock, new Dutch elm disease resistant shade trees are being developed.

Investigators working on the Dutch elm disease problem in the Netherlands have found several elms with a high degree of disease resistance among the commonly susceptible European elm species (fig. 7). The best of these are two selections of the smooth-leaved elm (*Ulmus carpinifolia* Gleditsch.) that have been named the Christine Buisman and the Bea Schwarz elms. The Christine Buisman elm has been tested and released by the U.S. Department of Agriculture to nurserymen in the United States, and stock of this selection is now available from commercial nurseries. This selection is resistant to both the Dutch elm disease and elm phloem necrosis, a destructive virus disease of elm. Its weaknesses are that it is sometimes heavily damaged by the elm-leaf beetle, and young stock has not proved to be hardy in such northern States as Iowa, Minnesota, and North Dakota.

In our tests the Bea Schwarz elm has not had as desirable a growth habit as the Christine Buisman elm. It is available only from the Netherlands.

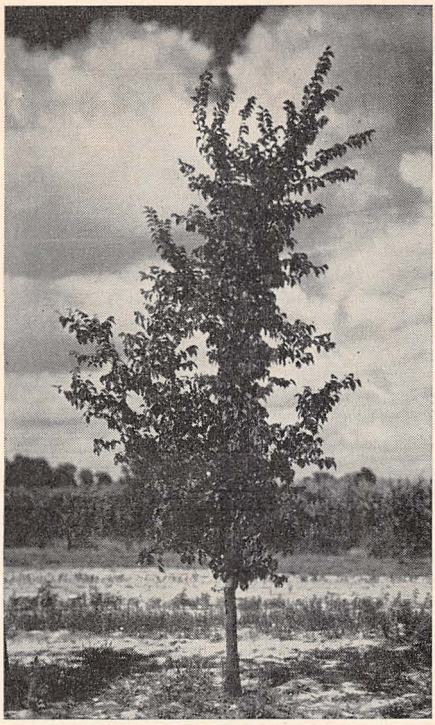

FIGURE 7.—The Christine Buisman elm is resistant to both the Dutch elm disease and phloem necrosis.

SUMMARY

The principal carrier of Dutch elm disease in the United States is the smaller European elm-bark beetle. At present the best way to control Dutch elm disease is to control its insect carriers. There is no cure once the elm trees become affected by Dutch elm disease. Elm-bark beetles and the Dutch elm disease fungus may become established in an area several years before the first appearance of Dutch elm disease. Spraying healthy elm trees is effective in protecting them against Dutch elm disease. Sanitation will reduce elm-bark beetle populations and should supplement the use of sprays for Dutch elm disease control. As a sole means of control, sanitation is usually ineffective. Control of elm-bark beetles by sanitation should be started as soon as they are found in an area. This may delay the occurrence of Dutch elm disease. Elms susceptible to the Dutch elm disease should not be planted in areas where the disease occurs. Elms resistant to Dutch elm disease are being developed.

This bulletin supersedes Leaflet No. 329, Control of Dutch Elm Disease and Elm Phloem Necrosis.

Washington, D.C.

Issued December 1958
Revised March 1964

U.S. GOVERNMENT PRINTING OFFICE: 1964

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 10 cents